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COMPARATIVE ANALYSIS OF WOODY PLANTS BIOMASS ON THE AFFECTED AND RESTRICTED LAND MANAGEMENT PRACTICES IN PEASANT COMMUNITY, ADAMAWA STATE, NIGERIA

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ABSTRACT
There are differences in woody plant distribution and sizes on the affected and restricted land management practices in rural areas. The aim of the study is to determine the difference in woody plants biomass on the adopted land management practices. The data required are distribution, height and girth of woody plant stands that were generated from the field using sample quadrats and measuring tape. The scope covers indigenous woody plants height, girth, distribution and biomass per unit area on the continuous cultivation, fallow and reserve lands. The biomass was determined using equations $B = (\pi r^2 h)$ to estimate single tree stand while $B = \pi(\bar{x}r^2) \times \bar{x}h(n)$ for stands that are more than one. The results were analyzed by comparing the magnitude of biomass per land management practices and unit area covered. The result revealed that reserve land have the highest biomass and cover more area than the affected. The result recommends preservation of seedlings of woody plants during annual clearance and clean weeding on continuous cultivation lands. The result implies with increase in continuous cultivation leads to reduction in plant biomass.

Keywords: Indigenous woody plants; Height; Girth; Distribution; Biomass

INTRODUCTION

From the concept of “Environmental Quality” that measures the condition of an environment relative to the requirements to human needs. The environment provide range of resources such as water, land, minerals and vegetation from which individual may choose to exploit based on his needs and norms (Wikimedia Project, 2017). Bigelow and Borchers (2017) observed that different landuse such as arable farming, pastoralism, settlement expansion; mining and construction that exist globally adversely affect vegetation cover. Results of studies pointed out that mining, construction and expansion of roads and settlements though are elements of development, but degrade vegetation cover (Israel, 2017; Sourceable Editorial Team, 2017; Adewole *et al,* 2007). These innovations reduce vegetation density, spatial coverage and inhibit regeneration because of the concrete surfaces and frequent utility of the affected areas. Pfiffner (2013) in study on effects of intensive landuse on biodiversity revealed that the decades of continuous farming have played a significant role in causing vegetation to radical change. This is due to the intensive introduction of exotic species, habitat change and fragmentation as well as scrub encroachment in the cultivated landscape.

Studies on effects of human activities on vegetation revealed that the woody plant cover of the Sudan region is relatively sparse, short and have narrow girth. This is because of climatic factors such as inadequate and seasonal rainfall. More importantly, the scanty woody plant cover is further affected adversely by diverse human activities such as frequent burning, rotational bush fallow, wood products harvesting and infrastructural development (Gandapa, 2014). Sahoo and Davidar (2013) on their study on effects of harvesting pressure on environmental resources maintained that vegetation cover was significant and adequately protects the surface from water erosion before the 1950s. This is because the population was low and the technology of resource exploitation was undeveloped. Therefore, soil fertility and vegetal resource harvesting were very low, and there was insignificant expansion of road networks and settlements.

Ndamase (2012) stated that the implications of the increasing and diverse environmental resources extraction shows that the vegetation that protects the soil from erosion, increases infiltration, retains soil moisture, provides wildlife habitat and vegetal products is degrading due to unwise harvesting. Gandapa (2014) in study on the relationship between human population and vegetation cover in Hong Local Government Area revealed that there is significantly negative correlation ($r = -0.75$) with percentage of determination of 56%. The result implies with increase in population there is a decrease in vegetation cover and vice versa. Consequently, with increase in population exhibited by diverse activities such as arable farming, infrastructural development and vegetal products harvesting there is decrease in woody plant cover. Therefore, it is significant to assess the biomass of indigenous woody plants on the affected and restricted land management practices in Hong Local Government Area.

Research on environment revealed that vegetation cover is the most observable resource that is affected significantly by human activities such as arable farming (Jiang *et al.,* 2017). Gandapa (2014) analyzed vegetation cover of Hong Local Government Area using landsat images. The result revealed that there is decrease in area covered by vegetation. The decrease is due to increase in population manifested by diverse human activities such as arable farming and wood harvesting. Furthermore, result of field observation indicates there is difference in the sizes of woody plants on the affected and restricted land management practices.

The studies of Gandapa (2014); Pfiffner (2013); Sahoo and Davidar (2013) have significantly identified the declining condition of vegetation cover and the causes. However, the studies did not identify the structures of vegetation cover that is significantly affected by human activities neither assessed distribution of woody plant stands nor compute the magnitudes of plants biomass on the affected and restricted land management practices of Hong Local Government Area. These conditions have necessitated the need to categorize the distribution, height and girth of indigenous woody plant stands on the continuous cultivation, fallow and reserve land management practices in 2014 to establish the differences in biomass.

The spatial scope covers Hong Local Government Area of Adamawa State. The issues assessed are specific human activities that affect indigenous woody plant. Varied land management practices: continuous cultivation, fallow and reserve lands. The parameters measured are woody plants' distribution, height and girth that are the basic variables required to determine the biomass and relative area covered in 2014. Distribution, height, girth and biomass were assessed because they are the most important woody plant components that cover the Earth's surface from the adverse effects of erosion and heat from the sun. Quantities of vegetal resources harvested remain largely unassessed.

Geographical Background to the Study Area

Hong Local Government Area lies between latitudes 09^{0}57'N to 10^{0}32'N and between longitudes 12^{0}38'E to 13^{0}16'E. It is located in Sudan region (Online Nigeria, 2002; Aregheore, 2002). The vital climatic elements that relate to woody plant size are rainfall and temperature. The dry season is usually experienced from the months of November to April of the following year while the wet season is from May to October every year. The mean annual rainfall varies between 700 to 1000mm. The mean daily temperature is between 36^0 to 41^{0}C of the dry season to about 20^0 to 25^{0}C during the wet season (Online Nigeria, 2017). The long dry season and high temperature affects woody plants development by inducing soil desiccation with adverse effects on wilting and withering; reduce increase in height, girth and distribution as well encourages seasonal bush fires that burn the bark.

The area is hilly with elevation ranging from about 426 to 1158m above mean sea level (Garkida, Nigeria, Sheet 155). The hilly terrain and compacted soils reduce development of crowded, tall and huge woody plants with exception on the sedimentary rocks on the basin of rivers Fa'a, Dogwaba and Bubulum that had crowded woody plant covers, but are significantly cleared for cultivation of crops such as sugar cane and rice. The vegetation lies within Sudan zone (Online Nigeria, 2002; Aregheore, 2002) characterized by short, scattered and wiry woody plants that are harvested for fuelwood, shelter materials, native food ingredients such as fruits and vegetables. The woody plants are massively cleared for arable farming, infrastructural developments, and significantly affected by bush fires and grazing.

The population increased from 112,845 in 1976 to170,452 in 2009 occupying an area of about 2,486km^2. The density increased from 45 persons per sq. km. in 1976 to 69 in 2009 while hectare per person decreased from 2.2 to 1.4. This implies there is increase in sizes of farmlands, built-up areas, and more demand on fuelwood with adverse effects on decrease in woody plants cover. Moreover, the predominant economic activities that affect woody plants are arable farming, bush burning, pastoralism and wood harvesting. Rotational bush fallow is the most single factor that significantly reduces woody plant cover, for the reason that the forward and backward rotation to the reserve and fallow lands reduces distributions of both primary and secondary woodlands.

MATERIALS AND METHODS

The types of data required for this study are socio-economic activities such as methods of crop production; woody plants characteristics such as distribution, height, girth; and types of land management practices. Data on woody plants distribution, girth and height were generated from the field by measurement using measuring tape while those on specific socio-economic activities of the people were generated through informal discussions with the people. Likewise, data on population and background to the study were obtained from published relevant materials.

Quadrat sampling technique was adopted to demarcate sample sites within which to generate data on live woody plants height, girth and distribution. This is an effective technique for generating observable data on woody plants parameters (Gandapa, 2014; Jamala *et al.,* 2012; Minnesota Project, 2012). Vodopich (2010) stated that the sample quadrat is the most widely used method to demarcate study plots within which to measure distribution of plants in terrestrial communities. The instruments used are a clinometer to determine height of tall trees; measuring tape to determine directly height of short trees and the girth. More importantly, dimensions of the quadrats were constructed using measuring tape and plastic netting (nylon) rope.

The height of each standing woody plant was determined from the ground surface at the base to the highest apical meristem. A clinometer was used to determine the height of woody plants (American Forest Measuring Guidelines, 2013; Offwell Woodland and Wildlife Trust, 2010). However, where because of its limitation to generate data on specific tree height on the reserve land due to lack of adequate bare space to view the apex and distance (base line) between the observer to the base of the tree, measuring tape, and a fairly straight and long pole were adopted. The uniform size (100m^2) and shape (square) of the quadrats were adopted because the plot was ideal for observing woody plant stands in the area characterized with sparse woody plant cover, but small enough to count all woody plant stands in a reasonable time. The micro areas facilitate in-depth observations and measurements of woody plants structures such as distribution, girth and height.

Stratified sampling method is used to locate sample quadrats within which to observe woody plants distribution, height and girth (Emmanuel, 2010). To cover the study area within a limited time, stratified sampling techniques was adopted. The study area was divided into 6 strata that served as a guide to locate the quadrat samples. Within each stratum, 3 sample plots that are physically heterogeneous and have different woody plant characteristics were chosen purposively for measuring distribution, height and girth. Purposive sampling technique was used to select areas within the identified land management practices where woody plant stands were available for observations and measurements. A total of 18 sample quadrats were established with 6 on each of the fallow, reserve and continuous cultivation lands as shown on

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Figure 1. In establishing the 3 sample quadrats in each stratum, areas such as built-up surfaces (road and settlement), water body and bare rock outcrops were excluded from the sampling sites because there is no plant growth on them. Simultaneously, standing, live and indigenous woody plants within the quadrats were counted and measured.

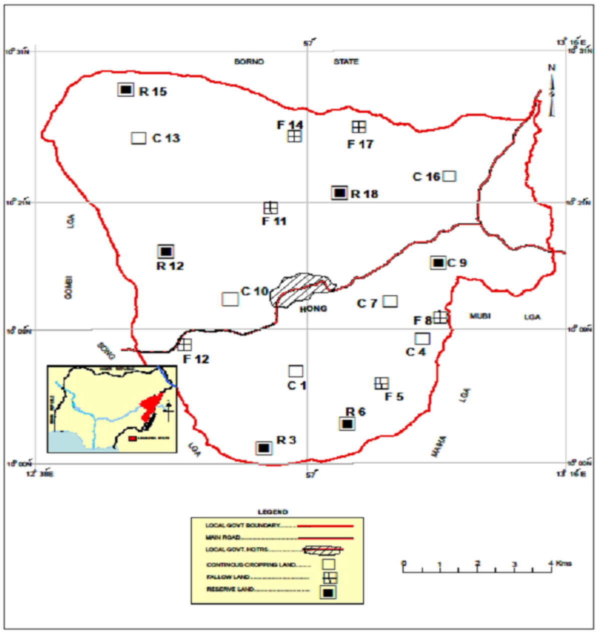

Figure 1: Study Area Showing Distribution of Quadrat Samples

Biomass is an important material used to determine surface coverage, because standing woody plants at a point in time covers the surface of a unit area. Yarie *et al* (2007) in research on plant biomass adopted equation (M = aDb) (*Equation 1)* for the Total Above Ground Biomass Estimates which was based on specific tree species to measure energy (carbon content) potential of forest for 65 trees; where *M* = over dry weight of the tree (kg), *D* = diameter at breast height (cm), *a* = parameter, and *b* = biomass. Brower *et al* (1997) in their research on estimation of weight of biomass per unit area adopted equation B = $\sum \frac{W}{A}$ (*Equation 2*); where *B* = biomass (grams per sq. m. or kg per hectare), $\sum$W = sum of the weights of the individual plants in a sample, and *A* = total area sampled. Gandapa (2014) adopted equation $B = (\pi r^2 h)$ (*Equation 3*) to estimate single tree stand while $B = \pi(\bar{x}r^2) \times \bar{x}h(n)$ (*Equation 4*) for stands that are more than one. Thus, B = biomass (m^3 per 100sq.m.), π = 3.14, r = $c/2\pi$, $\bar{x}h$ = average height, *h* = height of woody plant, and *n* = number of woody plants observed. These formulae ($B = (\pi r^2 h)$, and $B = \pi(\bar{x}r^2) \times \bar{x}h(n)$) utilize the variables derived from the physical measurements of the girth, height and distribution of the woody plants per 100sq.m., but excludes the leaves because they are plenty in number and small in sizes which make it impractical to account for their biomass. There is discrepancy in parameters measured, that is, energy potential Yarie *et al* (2007); weight of biomass Brower *et al* (1997) while Gandapa (2014) estimated woody biomass. However, there is similarity in all the methods by adopting tree characteristics such as sum, diameter and height that are derived from the physical measurements. To estimate biomass on the affected and restricted land management practices equation $B = (\pi r^2 h)$ was adopted for single tree stand while $B = \pi(\bar{x}r^2) \times \bar{x}h(n)$ for stands that are more than one. The generated data on distribution, height, girth and biomass per land management practices are presented by comparison per unit area.

RESULTS AND DISCUSSIONS ON FIELD OBSERVATIONS AND MEASUREMENTS

Results of the measured and observed woody plant structures such as distribution, height, girth and biomass are presented below.
Table 1 presents summary of woody plants distribution, height, girth and biomass on continuous cultivation, reserve and fallow lands

Table 1: Summary of Woody Plants Distribution, Height, Girth and Biomass on Continuous Cultivation, Reserve and Fallow Lands

Land Mgt. Practices	Quadrat No	Woody Plant Stand	Average Height (m)	Average Girth (m)	Biomass (m^3)	% of Area Covered	% of Area Uncovered
Continuous Cultivation Land	1	1	9.30	2.10	3.18	3.18	96.82
	4	-	-	-	-	-	-
	7	-	-	-	-	-	-
	10	1	11.80	1.98	3.79	3.79	96.21
	13	-	-	-	-	-	-
	16	1	13.00	1.59	2.55	2.55	97.45
	Total	**3 (1.66%)**	34.10	5.67	**9.52**	**9.52**	**290.48**
	$\bar{x}$ per quadrat	**1**	**5.68**	**0.95**	**1.59**	**1.59**	**98.41**
Fallow Land	2	12	2.61	0.17	0.03	0.03	99.97
	5	18	2.66	0.29	0.12	0.12	99.88
	8	21	2.39	0.18	0.05	0.05	99.95
	11	27	3.04	0.23	0.13	0.13	99.87
	14	15	2.38	0.25	0.06	0.06	99.94
	17	6	2.38	0.25	0.02	0.02	99.98
	Total	**99 (54.70%)**	15.46	1.37	**0.41**	**0.41**	**599.59**
	$\bar{x}$ per quadrat	**17**	**2.58**	**0.23**	**0.07**	**0.07**	**99.93**
Reserve Land	3	6	13.75	1.63	17.33	17.33	82.67
	6	12	11.16	1.30	17.40	17.40	82.60
	9	12	7.78	0.57	0.08	0.08	99.92
	12	30	10.60	0.36	1.14	1.14	98.86
	15	18	9.80	0.49	3.53	3.53	96.47
	18	1	8.13	1.81	2.11	2.11	97.89
	Total	**79 (43.64%)**	**61.22**	**6.16**	**41.59**	**41.59**	**558.41**
	$\bar{x}$ per quadrat	**13**	**10.20**	**1.03**	**6.93**	**6.93**	**93.07**
	Grand Total	**181**			**51.52**	**51.52**	**48.48**

Source: Field Study, 2014

Based on the result of this study, there are 181 woody plant stands observed on the 18 sample quadrats measuring 1800sq.m. Thus, stands varied from 99, 79 and 3 on fallow, reserve and continuous cultivation lands accordingly. The plants formed a biomass of 51.52m^3 that covers 51.52% of the sample areas (1800sq.m.) with 48.48% uncovered. Based on the findings on woody plants distribution, height and girth on the three different land management practices compared, fallow land has the highest distribution with 99 stands followed by reserve with 79 while continuous cultivation has the least with 3 stands. There are also variations in height. For example, continuous cultivation land has the highest tree stand with 11.37m; reserve has 10.20m while the shortest occur on the fallow land with 2.58m. Furthermore, woody plants on the continuous cultivation land have the widest girth with 1.98m; reserve has 1.03m while plants with the narrowest girth (0.23m) are observed on the fallow land.

Differences in Biomass between the Land Management Practices Compared (600sq.m.)

The results of biomass on the three different land management practices compared revealed that woody plants on the reserve land has the highest biomass with 41.59m^3 which covers 41.59% of the sample area (600sq.m.) with 58.41% uncovered. The occurrence of the highest biomass is attributed to the 79 stands per 600sq.m. with average girth and height of 1.03m and 10.20m accordingly. On the continuous cultivation land, the biomass is lower (9.52m^3) than the reserve land, but covers 9.52% with 90.48% uncovered. The reason for the lower biomass (9.52m^3) despite the trees are tall (11.37m) with the widest girth (1.89m) is due to 3 stands per 600sq.m. Apart from the 3 preserved economic trees (*Parkia biglobosa*, *Prosopis Africana*, and *Vetellaria paradoxa*) there are no other woody plants managed by the farmers against the adverse effects of annual clearing and clean weeding. Fallow land on the other hand has the least biomass with 0.41m^3 which covers 0.41% of the area (600sq.m.) with 99.59% uncovered. The reason for the least biomass (0.41m^3) is the trees are very short (2.58m) with narrow girth (0.23m) despite the 99 stands per 600sq.m.

The reasons for the insignificant biomass and lower surface coverage on the affected land management practices (fallow and continuous cultivation) is attributed to human activity such as continuous crop farming that massively remove woody plants. Furthermore, the newly invaded woody plants on the fallow lands are not allowed to develop into maturity, but are repeatedly cleared within a short fallow period of about five years. Nevertheless, the reserve land has a biomass of 41.59m^3 which cannot cover half of the sample area (600sq.m.) despite its restriction against intervention. This is because the woody plants are selectively harvested; there are some areas with few stands, for example, quadrat No.18 has a single stand of *Parkia biglobosa* that have established itself and by colonization deprive any new invading species from survival; and some of the stands are short (2.0m) with narrow (14cm) girth that account for a low biomass.

Variations in Biomass per Land Management Practices (100sq. m.)

From the results, there are differences in biomass amongst the three heterogeneous lands, namely, continuous, fallow and reserve land management practices compared. Woody plants on the reserve land have the largest biomass with 6.93m^3 that covers 6.93% of 100sq.m. with 93.07% uncovered. The occurrence of the largest biomass is due to the 13 stands that are tall (10.20m) with girth of 1.03m. Continuous cultivation land on the other hand has 1.59m^3 that covers 1.59% with 98.41% uncovered. The reason for the lower biomass is attributed to a single stand despite the widest (1.89m) girth and tallest (11.37m) stand while fallow land has the least biomass with 0.07m^3 that covers 0.07% of the area with 99.93% uncovered. The reason for the occurrence of the least biomass is attributed to very short stand (2.58m) and narrow (0.23m) girth despite the 17 stands per 100sq.m.

Based on the findings of this study, it can be stated that farmlands that are on fallow has the least woody plants' height, girth and biomass. This is because the newly invaded saplings are yet to be fully developed. Furthermore, all necessary plant parameters such as girth, height and biomass expected of a matured woody plant that contribute significantly to vegetal resources are not well developed on the fallow lands. This is because the secondary woodlands have suffered from soil disturbance like plowing. If given required time to regenerate to their initial state, they can acquire the characteristic of woody plants on the reserve lands.

From the result, it can be stated that the woody plant cover of the area is sparse. Most of the surfaces remain uncovered due to human activities such as arable farming, bush burning, grazing, selective logging and lopping which affects the woody plants density and biomass. With these low density and biomass woody plants cannot increase in number and density naturally. This is because matured plants are affected adversely by selective cutting and the seedlings by repeated bush burning.

The implication of the low crowdedness and biomass on the study area indicates the surface is not protected from the adverse effects of weather such as erosion, heat and wind that obstruct plants regeneration. The low woody plant distribution, height, girth and biomass affect environmental resources such as soil and surface water like Fa'a, Bubulum, Ngilang and Dogwaba by erosion and siltation with broader disadvantage on reduction in aquatic lives. More importantly**,** with increase in population manifested by diverse socio-economic activities such as arable farming, fuelwood harvesting and infrastructural development accelerates degradation of woodlands in the area by conversion to grassy and secondary woodland covers. Likewise, the low distribution, height, girth and biomass encourage the growth of diverse varieties of grasses. This is because there is insignificant woody plant materials that smother the grasses

Conclusion

Based on the findings of this study, arable farming is the most important single factor responsible for the identified variation in woody plants distribution, height, girth and biomass in the area because of the continuous cultivation, and forward and backward rotational bush fallow in search of fertile soil. There are 181 woody plants observed on the 1800sq.m. sample area that produced a total biomass of 51.52m^3 which covers 51.52% of the area. Among the three different land management practices compare fallow land is the most devastated in woody plants' height, girth and biomass. Furthermore, the woody plants' distribution is affected significantly on the continuous cultivation land with three stands on 600sq.m.

Recommendations

Based on the findings of this study, the following recommendations are made for sustainable management of woody plants distribution, height, girth and biomass in the study area. This research calls for investigation on other profitable and non-farming economic activities that could be undertaken to reduce the over dependence on arable farming especially the forward and backward rotational bush fallow which effects woody plants adversely. Furthermore, for significant conservation of woody plants distribution, height, girth and biomass reserve lands should be ear-marked and regulations be established to strictly prohibit any form of human intervention such as bush burning, massive and selective tree removal. More importantly, although arable farming cannot be stopped among the peasant communities, farmland management practices such as preservation of woody plants seedlings and saplings should be encouraged so as to increase distribution and biomass on continuous cultivation lands.

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